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**GUIDANCE FOR PERFORMING TESTS
ON DREDGED MATERIAL TO BE DISPOSED OF
IN OPEN WATERS**

Prepared by:

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and

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**in cooperation with the
National Marine Fisheries Service
and the
U.S. Fish and Wildlife Service**

DRAFT

Effective date: May 15, 1989

TABLE OF CONTENTS

	<u>PAGE NO.</u>
I. INTRODUCTION	3
II. ADMINISTRATIVE REQUIREMENTS	4
III. SELECTION OF SAMPLING SITES	7
IV. SAMPLING SITE FOR REFERENCE SEDIMENT	8
V. SAMPLING SITE FOR CONTROL SEDIMENT	8
VI. PHYSICAL TESTING	9
VII. BULK SEDIMENT ANALYSIS	10
VIII. TIERED EVALUATION TESTING REQUIREMENTS	10
1. Liquid Phase Assay	16
2. Suspended Particulate Assay	16
3. Whole Sediment Assay	16
4. Bioaccumulation Analysis	19
IX. ELUTRIATE TESTING	24
X. QUALITY ASSURANCE PROGRAM	24
1. Field Collections	24
2. Sediments/Tissue Analyses	25
3. Bioassay/Bioaccumulation Testing	26
4. Internal Laboratory Quality Assurance	27
5. Laboratory Inspections	27
XI. REFERENCES	29
APPENDIX A	31
APPENDIX B	32

I. INTRODUCTION

5/15/89

The enclosed material presents the sediment testing guidelines for permit applicants who wish to dispose of dredged material in open waters. It includes all disposal activities subject to the regulatory jurisdiction of the U.S. Army Corps of Engineers New England Division (COE, NED) under Section 103 of the Marine Protection, Research and Sanctuaries Act (P.L. 92-532) and Section 404 of the Clean Water Act (P.L. 92-217). It also includes other administrative requirements for processing an application for Department of the Army approval. These guidelines have been prepared by the Environmental Protection Agency (EPA), Region I and the COE/NED in cooperation with National Marine Fisheries Service and the U.S. Fish and Wildlife Service. Use of this protocol assumes that the permit applicant has already demonstrated the need for open water disposal and that all practicable alternatives to ocean disposal (40 CFR 227.15) or 404 disposal (40 CFR 230.10 (a)) have been explored and found unavailable or unfeasible according to the guidelines.

In accordance with Section 227.27(b) of EPA's Ocean Dumping Regulations and Criteria (Federal Register, Vol. 42, No. 7, Tuesday, 11 January 1977) an Implementation Manual entitled Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters (EPA/COE 1978) was developed jointly by the COE and EPA to define procedures for evaluating potential environmental impacts associated with ocean disposal of dredged material. The Implementation Manual presents national guidance concerning technical procedures and "is intended to encourage continuity and cooperation between COE Districts and EPA Regions in evaluative programs for Section 103 permit activities". Though the Implementation Manual presents detailed procedures for conducting tests required by EPA's Ocean Dumping Criteria, additional guidance is necessary to adapt the procedures to Regional situations. For instance, Regional guidance is needed to inform applicants of specific procedural items such as selection of bioassay organisms, chemical constituents required to be analyzed in bioaccumulation tests, etc. In addition, this manual summarizes the tests to be performed and the types of data to be submitted to the COE/NED so as to avoid any unnecessary confusion and possible delays in the permit review process through the submission of improper data. The COE will then forward the data to EPA and the other appropriate Federal resource agencies.

5/15/89

New and more advanced testing procedures are continually being developed and refined by the research and development laboratories of the EPA and the COE. In addition, ongoing monitoring of the designated disposal sites in New England under the COE "Disposal Area Monitoring System" (DAMOS) will provide effects-based feedback to the regulatory process that will enable the regulators to make more refined, environmentally sensitive and efficient decisions concerning the open water disposal of dredged materials. As a result, this document will be revised annually to incorporate any modifications of the testing requirements.

Questions regarding any aspect of the testing requirements should be directed to:

U.S. Army Corps of Engineers
New England Division
Regulatory Branch
424 Trapelo Road
Waltham, MA 02254
617-647-8298

II. ADMINISTRATIVE REQUIREMENTS

5/15/89

When applying for Department of the Army approval to dispose of dredged material into open waters, all dredging permit applications for disposal in open water must contain the following information:

- a. Current information regarding the need for dredging, including volume and area to be dredged, extent of shoaling, interruption or changes in standard operations resulting from shoaling, any available documentation showing problems resulting from the shoaling, and any other pertinent information.
- b. The applicant is encouraged and required to explore beneficial use of dredged material or alternative disposal options before considering open water dumping. Documentation of this review of available alternatives to open water disposal and justification for rejection must be provided.
- c. If the request is being made under an existing Department of the Army maintenance dredging permit, include the permit number and a short description of the last maintenance dredging performed. Include any past test data for the project area, including any test data from dredging projects adjacent or contiguous to the proposed work.
- d. Dimensions of the disposal vessel (length, width and volume of hopper) and the type of disposal vessel (split hull or pocket) and duration of disposal operation the applicant plans to use, if available.
- e. Type of dredging equipment to be used (clamshell or hydraulic).
- f. Two copies of an 8-1/2" X 11" map showing the area to be dredged, the specific location of the proposed sediment sampling sites, a detailed bathymetric description of the area (soundings) and a drawing showing a cross-section of proposed dredging area. Areas of wetlands, submerged vegetation, such as eelgrass, intertidal flats, and shellfish beds within and in proximity (within 1/2 mile radius) to the proposed dredge area must be identified on the plan.

5/15/89

- g. Identify any known possible sources of contamination to the proposed dredged area. This should include a letter from the harbor master or U.S. Coast Guard indicating the presence of outfalls, spills, surface runoff and any other discharges.

Five (5) copies of items a-g must be submitted to the COE (Copies will be forwarded to EPA and other appropriate Federal Resource agencies). The applicant must contact COE/NED personnel to discuss the adequacy of the proposed sampling design prior to the field collections. COE/NED reserves the right to modify the sampling design, as well as the series of tests required.

Prior to commencement of sampling, the applicant should submit to the COE/NED the names of the analytical contractors and subcontractors who will be conducting the biological and chemical analyses and the dates, place and time the sampling is to be performed. A Corps inspector or representative may wish to be present during sampling to insure that all quality assurance/quality control measures are followed.

For more details, consult pamphlet EP1145-2-1 (COE 1985), USACOE Permit Program, A Guide for Applicants. This pamphlet is available at the following address:

U.S. Army Corps of Engineers
Regulatory Branch
424 Trapelo Road
Waltham, MA 02254

5/15/89

III. SELECTION OF SAMPLING SITES

Selecting the proper number and location of sampling sites within the area to be dredged is a crucial step in the testing procedures. The following factors must be considered when choosing a sampling scheme.

The areal extent and heterogeneity of the material to be dredged must be considered. It is important that the sampling sites adequately characterize the physical (i.e., grain size, & water) and chemical differences in the area to be dredged on both the horizontal and vertical planes. If the material varies greatly with depth, or if "new work" dredging is being undertaken, the applicant may be required to include additional core samples to determine vertical differences in physical characteristics and chemical concentrations. Vertical and horizontal sampling designs must meet COE requirements. Under certain circumstances compositing of physically and chemically similar sediments can be done to reduce the total number of samples. Such a sampling scheme would have to be justified by the applicant and approved by the COE in consultation with the other Federal agencies prior to any compositing.

The applicant must consider the existence of point source discharges in the area to be dredged, or other causes for concern, such as historical occurrence of spills (oil, toxic or bioaccumulative chemicals), landfills and EPA Superfund Sites within the same drainage area and outfalls which may affect the area to be dredged (including sewage, storm water, industrial, municipal, commercial or residential discharges into the waterway). The intent of the Ocean Dumping Criteria is to identify and limit the disposal of dredged material which pose unacceptable adverse effects on the marine environment. The applicant is obligated to develop a sampling scheme which adequately reflects those ends. The COE/NED will review the sampling scheme prior to implementation for adequacy to insure that these requirements have been met.

The applicant must supply an 8-1/2" x 11" project map and if possible, a NOAA chart of the proposed area to be dredged. The maps must indicate the location of core sampling sites and the length of core samples taken. As stated above, these maps must be submitted to COE for approval prior to the proposed sample collections. The date, place and time of sampling also must be provided to the COE prior to the collection.

5/15/89

When sediment testing has been completed, the applicant must submit five copies of the testing report to COE/NED. This report must include raw data for all tests as required by this manual, a map of the area to be dredged showing the specific locations of sediment and water sampling sites, the sediment sampling log and the name of the laboratory(s) which performed the tests. If upland disposal is being considered, appropriate elutriate and leachate tests may be required.

All testing and quality control procedures must be described, and analytical methods must be specified.

IV. SAMPLING SITE FOR REFERENCE SEDIMENT

If bioassays are required, reference sediment must be obtained from the natural marine environment at a location near the disposal site. The reference sediment must be of similar physical characteristics to the sediment of the disposal site but is from an area not influenced by the disposal of dredged material at the dumpsite. The purpose of the reference sediment is to simulate conditions at the dumpsite as if previous disposal of dredged material had not occurred. Reference sediment test results are compared to those of the proposed material to be dredged.

Location of Reference Sites:

Foul Area Disposal Site	42° 24.7'N	70° 32.08'W
Cape Arundel Disposal Site	43° 17.9'N	70° 26.02'W
Central Long Island Sound Disposal Site	41° 8.1'N	72° 50.06'W
New London Disposal Site	41° 16.2'N	72° 03.08'W
Portland Disposal Site	43° 38.6'N	69° 59.01'W
Rockland Disposal Site	49° 7.1'N	68° 58.07'W

** see last page*

V. SAMPLING SITE FOR CONTROL SEDIMENT

Control sediment for the solid phase bioassay is used to determine the health of the organisms relative to the testing conditions. When the average control mortality exceeds 10%, all solid phase bioassay testing must be repeated.

Control sediment can be collected from any uncontaminated intertidal estuarine area and may consist of fine grained or coarse (sand) material. The sediment should be checked annually for chemical constituents listed in Table I A to insure its uncontaminated nature. These data must be furnished to COE/NED with the report.

5/15/89

VI. PHYSICAL TESTING

The physical testing required for the evaluation of dredged material for ocean disposal is limited to grain size, total organic carbon analysis and water content determinations. Core samples must be collected to adequately represent the vertical and horizontal characteristics of the material to be dredged and must be of sufficient volume for conducting all required analyses. Unless valid justification for another sampling method is demonstrated, all core samples must include sediment to the depth of the proposed dredging and if an alternative method is contemplated, the New England Division should be contacted prior to field sampling in order to avoid the possibility of unacceptable test results.

Core sediment samples must be visually inspected for the existence of strata. A grain size analysis (Folk, 1974; Guy 1969) must be conducted for each distinct layer observed in the material to be dredged. In the event no stratification is observed, grain size analyses must be conducted on material from each sample. Data must include the percentage of gravel, sand, and silt/clay according to the following criteria:

Gravel: greater than or equal to 2.0 mm
Sand: less than 2.0mm but greater than 0.0625 mm
Silt/clay: less than 0.0625 mm

Grain size analysis must also be performed on a separate composite of the reference sediment used in the solid phase testing.

According to EPA's Ocean Dumping Criteria (Sec. 227.13(b)), the material to be dredged may be excluded from further testing if one or more of the following conditions prevail:

Dredged material is composed predominately of sand, gravel, rock or any other naturally occurring bottom material with particle sizes larger than silt, and the material is found in areas of high current or wave energy such as streams with large bed loads or coastal areas with shifting bars and channels; or dredged material is to be utilized for beach nourishment or restoration and is composed predominately of sand, gravel, or shell, with particle sizes compatible with material on the receiving beaches; or the material proposed

5/15/89

for dumping is substantially the same as the substrate at the proposed disposal site; and the proposed dredging site is far removed from existing and historical sources of pollution, thereby providing reasonable assurance that such material has not been contaminated by pollution.

If the applicant wishes to utilize one of the above exclusions, compliance with the exclusion criteria must be demonstrated by grain size data and other pertinent historical or site specific information.

VII. BULK SEDIMENT ANALYSIS

Bulk sediment analyses must be performed on sediment samples collected at the sites where grain size analyses are performed. The constituents to be tested, analytical methods and required detection limits are listed in Tables I A and I B. All procedures, unless authorized in writing by the COE must conform with the appropriate methods established in the EPA document "Test Methods for Evaluating Solid Waste" SW-846, Third Edition (EPA 1986). A minimum of 1000 grams must be collected for each sample. Sediment samples may be stored for up to 8 weeks at 4° C under dark conditions .

The acceptable analytical methods and required detection limits are listed in Table I A and I B. Appropriate sample preparation and cleanup procedures are referenced in the analytical methods. All data should be expressed in ppm or ppb based on dry weight of sample. Bulk chemical analyses must be performed and reported on all test and reference sediments used in the bioassay/bioaccumulation tests described below.

VIII. TIERED EVALUATION TESTING REQUIREMENTS

Dredged material which does not meet the exclusions of Sec. 227.13(b) (for Section 103 ocean disposal) or is suspected to be contaminated must undergo bioassay testing in accordance with Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters (EPA/COE 1978).

A general explanation of the tiered approach is shown on Figure 1 and described below.

Tier I - Review of Existing Data

The Tier I level is a determination of whether certain types and concentrations of contaminants are likely to be present in the sediments. This determination is made by historical review of all available information including, but not limited to, the following: Section 404 and 402 discharge

5/15/89

TABLE I A. Chemical constituents, EPA analytical methods and detection limits routinely used for chemical examination of proposed dredged material.

<u>Chemical Constituent</u>	<u>Analytical Method</u>	<u>Detection Limit (ppm)</u>
METALS		
Arsenic	7060, 7061	0.5
Cadmium	7130, 7131	0.1
Chromium	7190, 7191	1.0
Copper	7210	1.0
Lead	7420, 7421	1.0
Nickel	7520	1.0
Mercury	7471	0.02
Zinc	7950	1.0
ORGANICS		
PCBs (total)	8080	0.01
Pesticides	8080 ^a	0.02 ^a
Aldrin		
Chlordane		
pp-DDT, DDE, DDD		
Dieldrin		
Endosulfan I, II		
Endosulfan sulfate		
Endrin		
Endrin aldehyde		
Heptachlor		
Heptachlor epoxide		
α, β, δ , and γ Hexachlorocyclohexane		
Methoxychlor		
Toxaphene		
PAHs	8100, 8250, 8270 ^a	0.02 ^a
Benzo(a)anthracene		
Benzo(a)pyrene		
Chrysene		
Fluoranthene		
Phenanthrene		
Pyrene		
TOC	9060	0.1 ^b
%Water		1.0 ^b
Grain Size	Wet Sieve	# 4, 10, 40, 200

^a Includes all compounds listed.
^b units in %

5/15/89

Table I B: Additional chemical constituents^a, EPA analytical methods and detection limits used for the chemical examination of proposed dredged material.

<u>Chemical Constituent</u>	<u>Analytical Method</u>	<u>Detection Limit(ppm)</u>
METALS		
Antimony	7040, 7041	1.0
Beryllium	7090, 7091	0.1
Selenium	7740, 7741	0.1
Silver	7760	0.1
Thallium	7840	0.1
MISCELLANEOUS		
Cyanide	9010, 9012	2.0
Phenolics	9065, 9066	1.0
Isophorone	8090	0.02
2,3,7,8-TCDD (Dioxin)	8280	0.002
2,3,7,8-TCDF (Dibenzofuran)	8280	0.002
BASE/NEUTRALS		
Aromatic Hydrocarbons	8100, 8250, 8270 ^b	0.02 ^b
Acenaphthene		
Acenaphthylene		
Anthracene		
Biphenyl		
Benzo(b) fluoranthene		
Benzo(k) fluoranthene		
Benzo(e) pyrene		
Benzo(ghi) perylene		
Dibenzo(a,h) anthracene		
2-6-Dimethylnaphthalene		
Fluorene		
Indeno (1,2,3-cd) pyrene		
1-Methylphenanthrene		
1-Methylnaphthalene		
2-Methylnaphthalene		
Naphthalene		
Perylene		
Chlorinated Hydrocarbons		0.02 ^c
1,2-Dichlorobenzene	8010, 8020, 8250, 8270	
1,3-Dichlorobenzene	8010, 8020, 8250, 8270	
1,4-Dichlorobenzene	8010, 8020, 8250, 8270	
1,2,4-Trichlorobenzene	8010, 8120, 8250, 8270	
2-Chloronaphthalene	8120, 8250, 8270	
Hexachlorobenzene	8120, 8250, 8270	
Hexachloroethane	8120, 8250, 8270	0.04
Hexachlorobutadiene	8120, 8250, 8270	0.04
Hexachlorocyclopentadiene	8120, 8250, 8270	

5/15/89

TABLE I B. (Continued)

<u>Chemical Constituent</u>	<u>Analytical Method</u>	<u>Detection Limit</u>
Phthalates	8060 ^b	0.01 ^b
benzylbutylphthalate		
bis(2-ethylhexyl)phthalate		
diethylphthalate		
dimethylphthalate		
di-n-butylphthalate		
di-n-octylphthalate		
Halogenated Ethers	8110 ^b	0.02 ^b
bis(2-chlorethy)ether		
bis(2-chloroisopropyl)ether		
bis(2-chlorethoxy)methane		
4-Bromophenylphenylether		
4-Chlorophenylphenylether		
Organonitrogen Compounds		0.02 ^b
Benzidine	8250,8270	
3,3-Dichlorobenzidine	8250,8270	
2,4-Dinitrotoluene	8090,8250,8270	
2,6-Dinitrotoluene	8090,8250,8270	
1,2-Diphenylhydrazine	8090,8250,8270	
Nitrobenzene	8090,8250,8270	
N-Nitrosodimethylamine	8070,8250,8270	
N-Nitrosodiphenylamine	8070,8250,8270	
N-Nitrosodipropylamine	8070,8250,8270	
ACID EXTRACTABLES	8040 ^b	0.02 ^c
4-Chloro-3-methylphenol		
2-Chlorophenol		
2,4-Dichlorophenol		
4,6-Dimethylphenol		
4,6-Dinitro-2-methylphenol		
2,4-Dinitrophenol		0.1
2-Nitrophenol		
4-Nitrophenol		0.1
Pentachlorophenol		0.08
Phenol		
2,4,6-Trichlorophenol		
VOLATILES	8010,8240,8260 ^c	0.01 ^c
Acrolein	8030,8240,8260	0.1
Acrylonitrile	8030,8240,8260	0.1
Benzene	8020,8240,8260	
Bromoform		
Carbon tetrachloride		
Chlorobenzene		
Chlorodibromomethane		
Chloroethane		
2-Chloroethylvinyl ether		0.1

5/15/89

TABLE I B. (Continued)

<u>Chemical Constituent</u>	<u>Analytical Method</u>	<u>Detection Limit (ppm)</u>
Chloroform		
Dichlorobromomethane	8010,8246,8260	0.01
1,1-Dichloroethane		
1,2-Dichloroethane		
1,1-Dichloroethylene		
1,2-Dichloropropane		
1,3-Dichloropropylene		
Ethylbenzene		
Methyl bromide		
Methyl chloride		
Methylene chloride		0.1
1,1,2,2-Tetrachloroethane		
Tetrachloroethylene		
Toluene	8020,8240,8260	
1, 2-trans-Dichloroethylene		
1,1,1-Trichloroethane		
1,1,2-Trichloroethane		
Trichloroethylene		
Vinyl chloride		

^aChemical constituents on this optional list would be stipulated by the Corps of Engineers in cooperation with other Federal resource agencies.

^bIncludes all compounds listed.

^cIncludes all compounds listed unless otherwise noted.

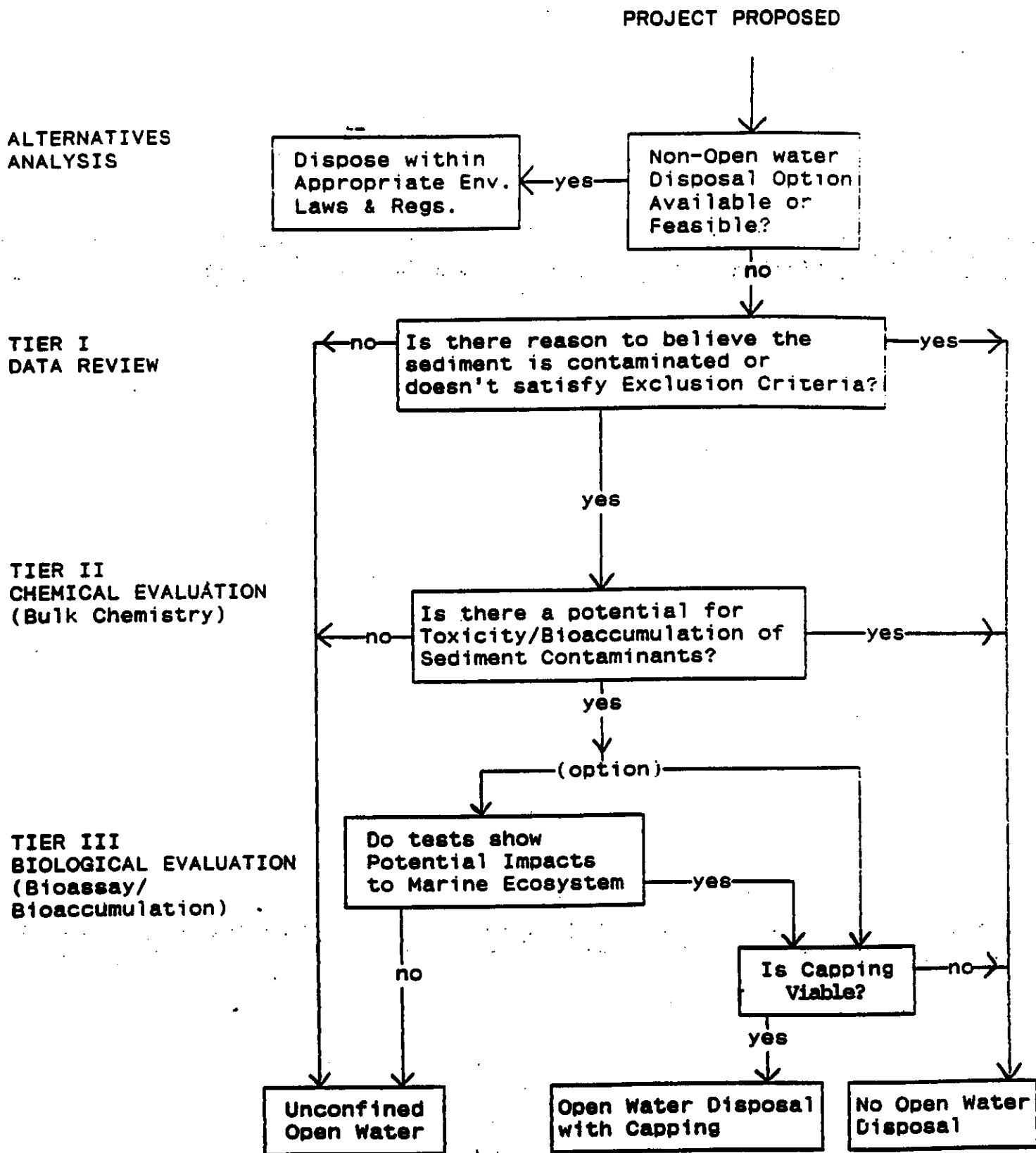


FIGURE 1. Generic Flow Diagram for the Tiered Testing and Decision Protocol for the Open Water Disposal of Dredged Material.

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5/15/89

permits; pollution spills; storm drains; unpermitted discharges; non-point sources including landfills and EPA Superfund sites within the same drainage basin; marine traffic, agriculture, industrial and commercial land use; upstream riverine pollution sources; and governmental private or academic environmental study in the area. If it can be determined by COE/NED that the dredged material meets the exclusion of Section 227.13, further testing will not be required. If not, Tier II is initiated.

Tier II - Chemical Evaluation of the Dredged Material

When Tier I investigations indicate potentially contaminated sediments, a bulk sediment and particle size analysis will be required. In general, grain size and the chemical constituents listed in Table I A will be required for most samples. Additional chemicals analytes listed in Table I B may be required on a case-by-case basis as determined by the Tier I analysis or consultation with the appropriate Federal resource agencies. Based upon these data, the COE will determine the need for Tier III testing.

Tier III - Biological Evaluation of the Dredged Material

The final tier consists of bioassay and bioaccumulation testing. All results of the bioassay/bioaccumulation testing must be submitted to the COE. Changes in sediment characteristics, as a result of discharges, shoaling or chemical spills that may have occurred in the interim between sediment collection and the submission of testing results, must be reported. Bioassay testing of the liquid phase is not required; however, the suspended particulate phase and elutriate testing may be required under certain circumstances. Whole sediment bioassays will be conducted (including controls and replicates) to determine the effect of the dredge material on appropriate marine species. It is the responsibility of the applicant to contact the COE/NED prior to commencement of testing to determine the series of tests required for each individual project.

5/15/89

1. Liquid Phase Assay

This testing procedure is no longer required on a routine basis unless specified by the COE.

2. Suspended Particulate Assay

A single suspended particulate phase sample refers to one homogenized suspension which undergoes assays with two different species, Mysidopsis bahia, and Menidia menidia (Table II). All procedures, unless authorized in writing, must conform to the guidelines established in the publication Ecological Evaluation of Proposed Discharge of Dredged Material Into Ocean Waters (EPA/COE 1978). During the suspended phase assays, assessments of sublethal effects must also be made and reported. Bioassays must be performed as follows:

Using a minimum of 20 specimens per replicate assay:

- Individual assays performed in triplicate on 100% control water and 100% suspended particulate.
- Individual assays performed in triplicate on 50% suspended particulate phase, the balance consisting of control water.
- Individual assays performed in triplicate on 10% suspended particulate phase, the balance consisting of control water.

Duration of assays should be a minimum of 96 hours with assessment of mortality and sublethal effects to be made and reported at 0 hours, 4, 8, 24, 48, 72 and 96 hours. Sublethal effects are defined as any obvious physical or behavioral abnormalities. These observations must be reported.

The above discussion outlines the minimum number of concentrations at which assays must be performed. If highly toxic conditions exist, such that at the 10% concentration, there is greater than 50% mortality, further dilution must be made in order to attain a greater than 50% survival, to develop an LC_{50} by interpolation. These dilutions, if necessary, must also be done in triplicate.

3. Whole Sediment Assay

A whole sediment sample refers to one homogenized sediment-slurry which under goes assays using the species listed in Table II.

5/15/89

TABLE II

Representative test species used for bioassay/bioaccumulation testing.¹

<u>SUSPENDED PARTICULATE</u>	<u>WHOLE SEDIMENT</u> ²	<u>BIOACCUMULATION</u> ³
<u>Mysidopsis bahia</u>	✓ <u>Ampelisca abdita</u>	<u>Nereis virens</u>
<u>Menidia menidia</u>	✓ <u>Nereis virens</u>	<u>Palaemonetes pugio</u> ⁴
	<u>Palaemonetes pugio</u> ⁴	<u>Macoma balthica</u>
	✓ <u>Macoma balthica</u>	<u>Yoldia limulata</u>
	✓ <u>Yoldia limulata</u>	<u>Mercenaria mercenaria</u> ⁵
	<u>Mercenaria mercenaria</u> ⁵	

¹ All species chosen must be approved by the Corps of Engineers prior to testing.

² Whole sediment bioassays must include three (3) species: a crustacean (preferably Ampelisca), the polychaete Nereis, and a bivalve (preferably Macoma or Yoldia).

³ Bioaccumulation testing must use survivors of the bioassay (except Ampelisca), including the polychaete Nereis, a bivalve (preferably Macoma or Yoldia), and Palaemonetes if it is used in the whole sediment bioassay.

⁴ This species may be used only if Ampelisca is unavailable.

⁵ This species may be used only if Macoma or Yoldia are unavailable.

5/15/89

All procedures, unless authorized in writing, are to conform to the guidelines established in the publication Ecological Evaluation of Proposed Discharge of Dredged Material Into Ocean Waters 1978 (EPA/COE 1978).

The sediments must be homogenized by mild agitation. The bioassay tests may be performed on particular sampling sites or on a composite of specified sampling sites within the proposed area to be dredged. The COE in cooperation with the Federal Agencies, will specify the appropriate sampling scheme on a case-by-case basis.

The sediments used for bioassays (both proposed dredged and reference materials) must be analyzed for the parameters listed in Table I A. The results of these analyses must be reported to the COE before starting the bioassay.

Water used for whole sediment bioassays must be of acceptable quality or if artificial seawater is used, it should be prepared as described in Standard Methods (APHA/AWWA/WPCF 1985). The salinity must be 30 ± 2 ppt, the pH 8.0 ± 0.2 , the water temperature $20 \pm 2^\circ\text{C}$ and the D.O. greater than 4 mg/l at all times. A minimum settling time of two hours must be allowed before seawater flow is initiated, additionally a two hour flushing time must be allowed before introduction of organisms.

The EPA, Region I, and COE/NED, have designated the species contained in Table II as "appropriate sensitive marine organisms" to be tested in the bioassays, in accordance with 40 CFR 227.

The flow-through system must provide 6 changes of water per 24 hours. The flow injection must be directed downward at 2" below the surface in order to achieve good mixing without disturbing the layer of sediment at the bottom. Five replicates for test and reference and three replicates for the control treatment must be run in separate aquaria; however, species may be combined in aquaria if organisms show compatibility in the natural environment. Measures should be taken to insure separation of predatory animals.

Laboratories must ensure that an adequate amount of animal tissue is available to conduct all required subsequent bioaccumulation analyses. For each species a minimum of twenty organisms for acute testing must be used to insure 30 grams of tissue (or enough tissue to achieve the appropriate detection limits in Table III) for bioaccumulation analysis. For each species to be tested (except *Ampelisca*), a subsample of 30 grams of tissue (or enough tissue to achieve the appropriate detection levels) should be analyzed for the specified constituents in Table III to determine baseline concentrations in the organisms. Aquaria must be a minimum of 10 gallons in size.

The amphipod toxicity test will be run separately in 1 liter glass jars following the methodology of Swartz et al. (1985). That reference should be consulted for details on procedure, apparatus,

5/15/89

animal handling and quality assurance.

All aquaria must contain the following layers of sediment for whole sediment testing:

Test treatment tanks - 5 cm (depth) of dredged material

Reference treatment tanks - 5 cm of reference sediment

Control treatment tanks - 5 cm of control sediment.

Whole sediment assays using organisms in Table II must be sub-sampled accordingly, using a minimum of 20 organisms per replicate.

Three replicate assays must be performed using the specified control sediment.

Five replicate assays must be performed using the specified reference sediment.

Five replicate assays must be performed using a homogenized solid phase sample.

The whole sediment assays must continue uninterrupted for 10 days, during which time daily records must be kept of salinity, temperature, DO, obvious mortalities and any sublethal effects. Formation of tubes or burrows and any physical or behavioral abnormalities must also be recorded. These daily records must be reported by the testing laboratory and submitted by the applicant. Organisms should not be fed during the test period.

All organisms surviving the solid phase must be placed in sediment free water for 24 hours to purge their digestive tracts of sediment. All surviving organisms must be analyzed.

4. Bioaccumulation Analysis

The tissue of all organisms (except Ampelisca) surviving the 10 day whole sediment bioassay test must be analyzed for those chemical constituents found at high levels in the bulk sediment analysis. Those constituents requiring analysis would be provided by the COE on a case-by-case basis. A list of potential pollutants along with the required analytical methods and detection limits are provided in Table III. Other constituents may be required for analyses whenever the COE in cooperation with the Federal resource agencies have reason to believe that they may be warranted. These most likely constituents would include a suite of metals, PCBs, pesticides and PAHs such as those listed in Table IA.

The procedures for the analyses will generally follow the methods described in EPA/COE (1978), Appendix G, with the following supplemental modifications.

5/15/89

Table III. Chemical constituents^a, EPA analytical methods and detection limits used for chemical examination of tissue.

<u>Chemical Constituent</u> (ppm)	<u>Analytical</u> <u>Method</u>	<u>Detection Limit</u>
‡ Lipids		0.1 ^b
‡ Water		0.1 ^b
METALS^c		
Antimony	7040, 7041	0.01
Arsenic	7060, 7061	0.01
Beryllium	7090, 7091	0.1
Cadmium	7130, 7131	0.1
Chromium	7190, 7191	0.2
Copper	7210	0.1
Lead	7420, 7421	0.5
Mercury	7471	0.01
Nickel	7520	0.2
Selenium	7740, 7741	0.01
Silver	7760	0.02
Thallium	7840	1.0
Zinc	7950	0.1
ORGANICS		
PCBs	8080	0.02
Pesticides	8080 ^c	0.002-0.03 ^c
Aldrin		
Chlordane		
p,p-DDT, DDE, DDD		
Dieldrin		
Endosulfan I, II		
Endosulfan sulfate		
Endrin		
Endrin aldehyde		
Heptachlor		
Heptachlor epoxide		
α,β,δ-γ-Hexachlorocyclohexane		
Methoxychlor		
Toxaphene		
MISCELLANEOUS		
Cyanide	9010, 9012	2.0
Phenolics	9065, 9066	1.0
Isophorone	8090	0.02
2,3,7,8-TCDD (Dioxin)	8280	0.002
2,3,7,8-TCDF (Dibenzofuran)	8280	0.002

5/15/89

TABLE III. (continued)

<u>Chemical Constituent</u>	<u>Analytical Method</u>	<u>Detection Limit</u>
BASE/NEUTRALS^d		
Aromatic Hydrocarbons	8100, 8250, 8270 ^e	0.01-0.02 ^{fe}
Acenaphthene		
Acenaphthylene		
Anthracene		
Biphenyl		
Benzo(a)anthracene		
Benzo(b)fluoranthene		
Benzo(k)fluoranthene		
Benzo(a)pyrene		
Benzo(ghi)perylene		
Benzo(e)pyrene		
Chrysene		
Dibenzo(a,h)anthracene		
2-6-Dimethylnaphthalene		
Fluoranthene		
Fluorene		
Indeno(1,2,3-cd)pyrene		
1-Methylphenanthrene		
1-Methylnaphthalene		
2-Methylnaphthalene		
Naphthalene		
Perylene		
Phenanthrene		
Pyrene		
Chlorinated Hydrocarbons		0.01 ^f
1,2-Dichlorobenzene	8010, 8020, 8250, 8270	
1,3-Dichlorobenzene	8010, 8020, 8250, 8270	
1,4-Dichlorobenzene	8010, 8020, 8250, 8270	
1,2,4-Trichlorobenzene	8010, 8120, 8250, 8270	
2-Chloronaphthalene	8120, 8250, 8270	
Hexachlorobenzene	8120, 8250, 8270	
Hexachloroethane	8120, 8250, 8270	0.04
Hexachlorobutadiene	8120, 8250, 8270	0.04
Hexachlorocyclopentadiene	8120, 8250, 8270	
Phthalates	8060 ^e	0.01 ^e
benzylbutylphthalate		
bis(2-ethylhexyl)phthalate		
diethylphthalate		
dimethylphthalate		
di-n-butylphthalate		
di-n-octylphthalate		
Halogenated Ethers	8110 ^e	0.02 ^e
bis(2-chlorethy)ether		
bis(2-chloroisopropyl)ether		
bis(2-chlorethoxy)methane		
4-Bromophenylphenylether		
4-Chlorophenylphenylether		

TABLE III. (Continued)
Chemical Constituent

Analytical
Method

5/15/89
Detection
Limit

Organonitrogen Compound

0.02^e

Benzidine	8250, 8270
3,3'-Dichlorobenzidine	8250, 8270
2,4-Dinitrotoluene	8090, 8250, 8270
2,6-Dinitrotoluene	8090, 8250, 8270
1,2-Diphenylhydrazine	8090, 8250, 8270
Nitrobenzene	8090, 8250, 8270
N-Nitrosodimethylamine	8070, 8250, 8270
N-Nitrosodiphenylamine	8070, 8250, 8270
N-Nitrosodipropylamine	8070, 8250, 8270

ACID EXTRACTABLES^d

8040^e

0.02^f

4-Chloro-3-methylphenol
2-Chlorophenol
2,4-Dichlorophenol
4,6-Dimethylphenol
4,6-Dinitro-2-methylphenol
2,4-Dinitrophenol
2-Nitrophenol
4-Nitrophenol
Pentachlorophenol
Phenol
2,4,6-Trichlorophenol

0.1

0.1

0.08

VOLATILES^g

8010, 8240, 8260^f

0.01^f

Acrolein 8030, 8240, 8260
Acrylonitrile 8030, 8240, 8260
Benzene 8020, 8240, 8260

0.1

0.1

Bromoform
Carbon tetrachloride
Chlorobenzene
Chlorodibromomethane
Chloroethane
2-Chloroethylvinyl ether
Chloroform

0.1

Dichlorobromomethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
1,2-Dichloropropane
1,3-Dichloropropylene
Ethylbenzene

8010, 8240, 8260

Methyl bromide
Methyl chloride
Methylene chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Toluene
1, 2-trans-Dichloroethylene
1,1,1-Trichloroethane

0.1

8020, 8240, 8260

5/15/89

TABLE III. (Continued)
Chemical Constituent

Analytical
Method

Detection
Limit

1,1,2-Trichloroethane
Trichloroethylene
Vinyl chloride

8010, 8240, 8260^f

0.01^f

- ^a Chemical constituents required for testing would be stipulated by the Corps of Engineers in cooperation with other Federal resource agencies.
- ^b Units in %
- ^c Follow Extraction/Cleanup Procedures described in Tetra Tech (1986b).
- ^d Follow Extraction/Cleanup Procedures described in Battelle (1985).
- ^e Includes all compounds listed.
- ^f Includes all compounds listed except otherwise noted.
- ^g Follow Extraction/Cleanup Procedures described in Tetra Tech (1986b).

5/15/89

Upon completion of the whole sediment testing, the screening organisms are placed in sediment free water for 24 hours to purge their digestive tracts of sediment. About 30 grams of tissue of each species are pooled, homogenized, digested or extracted for the analyte of concern. For semi-volatile organics, the sample preparation methods found in Battelle (1985) should be used. Tetra Tech (1986b) should be consulted for sample preparation methods for metals and volatile organics. The analytical methods of choice and required detection limits are provided in Table III for each analyte. A separate analysis must be conducted for each chemical constituent, for each individual replicate, and for each of the animal species in both test and reference treatments. Percent moisture and percent lipids must be reported for each species and treatment. Pretesting of the constituents of concern in the animal tissue must be performed and reported as discussed in the previous section.

IX. ELUTRIATE TESTING

If dredged material does not meet the exclusions of Sec. 227.13(b), and if suspended particulate phase testing is required, elutriate testing must be performed on three separate sediment samples from the area to be dredged. All procedures, unless authorized in writing, must conform to the modified procedures described in the publications Palermo (1986) and as amended by Palermo and Thackston (1988). The constituents to be tested are summarized in Table I A and I B. The procedures specified in 40 CFR Part 136 should be used.

Table I A represents the minimum number of contaminants to be tested in the chemical analysis of the elutriate. If there is knowledge of nearby sources of contamination which may be affecting the sediments to be dredged, the COE may require the testing of additional chemical contaminants. All data must be reported.

X. QUALITY ASSURANCE PROGRAM

To insure that data submitted are reliable and accurate, the EPA Region I and the COE/NED have developed the following field and laboratory quality assurance/quality control measures.

All laboratories providing analytical services to permit applicants must perform testing in accordance with the specifications described below.

1. Field Collections

- a. All sediment sampling plans and compositing strategies must be preapproved by the COE.

5/15/89

- b. All sampling must be taken by core (polycarbonate or butyrate tubes, gravity cores, borings) or grab samplers depending on the depth of the proposed dredging and the nature of the material. The COE must approve the sampling apparatus. A minimum of 1000 grams of sediment must be collected for bulk analysis. Field notes should be made on color, horizons, visual grain size, general cohesiveness and odors of the sediments. Care should be taken to avoid contamination from sampling gear, grease, ship winches or cables, airborne dust, ship engine exhaust, cross contamination and improper subsampling procedures.
- c. The applicant must notify the COE of the date, place and time of the field collections prior to the sampling date to afford a COE inspector or representative the opportunity to observe the collections.
- d. Sampling records must be maintained to document the field collection and chain of custody to the time of analysis. These records should include Field log books, sample labels, records of containers, time and conditions of storage. All sample containers and storage conditions will comply with the specifications in Chapter 2 of the EPA SW-846 Testing Methods for Evaluating Solid Wastes (EPA 1986). Records will be kept a minimum of 5 years.

2. Sediment/Tissue Analyses

- a. Sample Preparation: Singular or composite sediment samples should be homogenized and digested and/or extracted according to the procedures recommended in SW-846 (EPA-1986) appropriate for sediments. The methodologies for metals, volatiles and semi-volatiles may vary with the chemical constituent of interest. The appropriate cleanup procedures as described in the analytical methods should be used to remove interfering substances which can raise detection limits. If the required detection limits cannot be obtained, an explanation must accompany the data explaining in detail the reasons for not obtaining the detection limits. Sediment samples may be stored for up to 8 weeks at 4° C under dark conditions. The applicant is also referred to Tetra Tech (1986a) for specific guidance on sample preparation for marine and estuarine sediments.

The sample preparation methods for animal tissue described in Battelle (1985) are highly recommended for semi-volatile organic chemical constituents, whereas the method detailed in Tetra Tech (1986b) should be followed for metals and volatiles. As mentioned above, a minimum of 30 grams of tissue is required (or enough to obtain acceptable detection limits).

5/15/89

b. Analytical Procedures: As mentioned above, the analytical methods described in the EPA "Testing for Evaluating Solid Waste" (EPA 1986) should be used following the appropriate sample preparation. The methods listed in Tables IA, IB and III and the required detection limits should be followed for each chemical constituent. The analytical quality control measures described in each of these methods should be followed. Sample quality control guidance is provided in Chapter One of EPA (1986) where applicable. In particular, each run should include:

- (i) blank sample to evaluate potential contamination of the extract;
- (ii) spiked samples to determine % recovery;
- (iii) calibration checks at the beginning and end of each run to monitor instrument drift (additional checks may be required by the analytical method);
- (iv) sample replication to assess precision (in the case of animal tissues for the bioaccumulation testing, 3 sub-samples of the homogenate from one of the five replicates in the test treatments for each of the 3 species must also be analyzed for the chemical constituents of concern); and
- (v) analyses of sediment and/or tissue standard such as those available from the National Institute of Standards and Technology (Formerly the National Bureau of Standards) or the National Research Council of Canada. Information on acquiring these materials is provided in Appendix A of this document. This provide a check on extracation efficiencies and general analytical accuracy.

All data in i-iv should be reported on the appropriate Forms provided in Chapter One of SW 846 (EPA 1986).

The laboratory may also be required to analyze a "blind" sample on an annual basis to assess the lab's general performance. Failure to adequately perform these analyses or the above stated quality control measures will lead to rejection of the data by the COE.

3. Bioassay/Bioaccumulation Testing

All bioassay/bioaccumulation testing procedures must follow the methods outlined in EPA/COE (1978) with the modifications described in Sections D and E. All bioassays must be performed at 20° C (±2°) in either

5/15/89

natural seawater or a synthetic seawater adjusted to 30 parts per thousand salinity. If a synthetic seawater is used, the mixture must be allowed to age sufficiently prior to use. If natural seawater is used, the influent water must be checked at the start and finish of each test for all compounds that will be analyzed as part of the bioaccumulation testing.

Reference and control sediments must be collected from the locality specified in Section A. Bulk testing must be performed for each new batch of sediment.

Control bioassays must maintain an average of 90% survival rate among the replicates for each species tested. Failure to maintain the survival rates will invalidate the testing procedures and require retesting of the control, reference, and test samples. Standard toxicant tests must be performed on species used in the suspended particulate phases when this test is required. The procedures required for this test are described in Appendix B.

4. Internal Laboratory Quality Assurance

Before performing the tests, the laboratory must submit their current Quality Assurance Manual (QAM) for review by the regional COE/NED office. Once the QAM manual is accepted annually, only documentation of that approval is necessary. The manual should include the following:

- (a) A list of all analytical equipment (make, model and year) and devices used in the biological and chemical work, laboratory calibration methods, precision and accuracy standards, number of times standards are checked, maintenance schedules, record keeping methods, personnel responsibilities, and source of test animals.
- (b) Labeling system employed to ensure proper tracking of samples from collection through analysis to within the chain of custody procedure documented in the final report.

5. Laboratory Inspections

The laboratory facilities are subject to periodic inspection by COE/NED and EPA personnel. Original copies of data, records, and quality control concerning sediment testing for a client for a Department of the Army permit must be maintained for a period of at least five (5) years and must be available during laboratory inspections.

5/15/89

The COE/NED may require analysis of quality control samples by any laboratory for the purpose of determining compliance with its analytical requirements. Such samples shall be performed at least once per calendar year or as requested by the COE. The laboratory shall provide the COE/NED with the analytical results from such quality control samples upon request.

The COE/NED will periodically inspect laboratories for the purpose of evaluating their capabilities in performing the requirements specified in the Guidance Manual.

5/15/89

XI. REFERENCES

- APHA/AWWA/WPCF. 1985. Standard Methods for Examination of Water and Wastewater. 16th Ed. American Public Health Assoc., Washington, D.C. 1268 pp.
- Battelle. 1985. Method for Semivolatile Organic Priority Pollutants in Fish, Final Report. EPA Contract No. 68-03-1760 EPA, Washington, D.C.
- Environmental Protection Agency (EPA)/Corps of Engineers (COE). 1978. Ecological evaluation of proposed discharge of dredged material into ocean waters, April 1978. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.
- Environmental Protection Agency (EPA). 1986. SW-846 Test methods for evaluating solid waste. U.S. EPA, Office of Solid Waste and Emergency Response, Washington, D.C.
- Folk, R. 1974. Petrology of Sedimentary Rocks. Hemphill Publishing Co., Austin, TX.
- Guy, H.P. 1969. Laboratory Theory & Methods for Sediment Analysis. Book 5; U.S. Geological Survey, 55 pp.
- Palermo, M.R. 1986. Development of a Modified Elutriate Test for Estimating the Quality of Effluent for Confined Dredged Material Disposal Areas. Technical Report D-86-4. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
- Palermo, M.R. and E.L. Thackston. 1988. Refinement of Column Settling Test Procedures for Estimating the Quality of Effluent from Confined Dredged Material Disposal Areas. Technical Report D-88-9. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
- Swartz, R.C., W.A. DeBen, J.K.P. Jones, J.O. Lamberson and F.A. Cole. 1985. Phoxocephelid Amphipod Bioassay for Marine Sediment Toxicity. In: Aquatic Toxicology and Hazard Assessment; Seventh Symposium, ASTM STP 854, R.D. Cardwell, R. Purdy & R.C. Bahner (eds.). American Society for Testing and Materials, Philadelphia, PA pp. 284-307.
- Tetra Tech, Inc. 1986 a. Analytical Methods for U.S. EPA Priority Pollutants and 301(h) Pesticides in Estuarine and Marine Sediments. Final Report. EPA Contract No. 69-01-6938. Office of Marine & Estuarine Protection, EPA, Washington, D.C.

5/15/89

Tetra Tech, Inc. 1986 b. Bioaccumulation Monitoring Guidance:

4. Analytical Methods for U.S. EPA Priority Pollutants and 301(h) Pesticides from Estuarine and Marine Organisms. EPA Contract No. 68-01-6938. Office of Marine and Estuarine Protection, EPA, Washington, D.C.

U.S. Army Corps of Engineers (COE). 1985. USACOE Permit Program, A Guide for Applicants. Pamphlet EP1145-2-1. May, 1985. COE/NED, Waltham, MA.

5/15/89

Appendix A

Acceptable Standard Reference Materials Available in 1989

<u>Matrix</u>	<u>Sample Name & NO.</u>	<u>Analysis</u>	<u>Originator</u>
Coastal Marine Sediment	BCSS-1	Metals	NRCC ¹
Estuarine Sediment	MESS-1	Metals	NRCC ¹
Harbor Sediment	PACS-1	Metals	NRCC ¹
Estuarine Sediment	SRM 1646	Metals	NIST ²
Coastal Marine Sediment	CS-1	PCB	NRCC ¹
Harbor Marine Sediment(2)	HS-1,HS-2	PCB	NRCC ¹
Fresh Water Sediments	PCB in Sediments	PCB	US EPA ³
Sediments	SRM 1939,SRM 1940	PCB	NIST ²
(Avail.mid 89)			
Marine Sediments	SRM 1941	Organics	NIST ²
(Avail.mid 89)			
Harbor Marine Sediments(4)	HS-3,HS-4,HS-5,HS-6	PAH	NRCC ¹
Estuarine Sediment	SES-1	PAH	NRCC ¹
Estuarine Sediments	SRM 1647,SRM 1597	PAH	NIST ²
Lobster Tomalley	TORT-1	Metals	NRCC ¹
Dogfish Muscle	DORM-1	Metals	NRCC ¹
Dogfish Liver	DORM-1	Metals	NRCC ¹
Fish	Pesticides in Fish	Pesticides	USEPA ³
Tissue	_____	Metals/	NIST ²
(Avail. 1990)		Organics	

Send requests and price list to the following addresses:

- 1 National Research Council of Canada
Marine Analytical Chemistry Standards Program
Division of Chemistry
Montreal Road
Ottawa, Ontario, Canada K1A0R9
Telephone (613) 933-2359
- 2 National Institute of Standards & Technology
(NBS Standard Reference Material Catalog)
Office of Standard Reference Materials
Gaithersburg, MD 20899
Telephone (301) 975-6776
- 3 U.S. Environmental Protection Agency
Quality Assurance & Research Division
Rm. 525 EMSL-Cincinnati
Cincinnati, Ohio 45268
Telephone (513) 569-7325
Available free on limited basis(2 per quarter year)
Each has enough sediment/tissue for 2 runs

Appendix B

STANDARD TOXICANT TEST

All species used by the testing laboratory in the suspended particulate phase bioassays must undergo 96 hour acute toxicity tests using the standard toxicant Sodium Lauryl Sulfate (SLS) within 30 days of the date of the completion of the sample bioassay.

Laboratory grade SLS must be prepared immediately before use. Do not store stock solution of SLS.

Natural seawater may not be used as dilution water for Standard Toxicant Tests. Synthetic seawater must be prepared as previously described.

In general, the bioassay procedures described in the Ecological Evaluation of Proposed Discharge of Dredging Material into Ocean Waters, 2nd printing, April 1, 1978 (EPA/COE 1978), and Standard Methods, 16th Edition (APHA/AWWA/WPCF 1985), must be followed. Tests must be performed in duplicate using 10 organisms per replicate.

The following geometric series of toxicant concentrations must be used.

- a. Menidia menidia 5.0ppm, 2.5ppm, 1.3ppm, 0.6ppm, 0ppm
- b. Mysidopsis bahia 10.0ppm, 5.0ppm, 2.5ppm, 1.3ppm, 0ppm

If the highest concentration indicated above does not result in 50% mortality after 96 hours, progressively higher concentrations must be used until this mortality rate is obtained.

Control mortality must not exceed 10% or the the results are deemed unacceptable and the test must be repeated.

A summary of the standard toxicant test must be included in each Laboratory Report submitted to the COE/NED and must include the following information (one sheet per organism).

- a. Test organism species, source of specimens
- b. Test start date, test finish date
- c. Brand name of artificial seawater mix and length of time water was aged prior to use
- d. Toxicant brand name and grade
- e. The number of live organisms at
0, 4, 8, 24, 48, 72, and 96 hours
- f. Salinity temperature, pH and DO values
at 0, 24, 48, 72, and 96 hours
- g. Method of calculating LC50
- h. LC50 values with 95% Confidence Intervals

Updated Sampling Sites for Reference Sediment

(See Page 8)

Location of Sampling Sites:

Massachusetts Bay Disposal Site	42° 22.7' N	70° 30.30' W
Cape Arundel Disposal Site	43° 17.9' N	70° 26.02' W
Cape Cod Bay Disposal Site	41° 57.500' N	70° 16.000' W
Central Long Island Sound Disposal Site	41° 8.1' N	72° 50.06' W
New London Disposal Site	41° 16.7' N	72° 2.0' W
Portland Disposal Site	43° 38.6' N	69° 59.01' W
Rockland Disposal Site	44° 7.09' N	68° 58.70' W

August 13, 1998